

**Method and Device for Producing a Peripherally Closed Hollow Profile**

**CROSS REFERENCE TO RELATED APPLICATIONS**

[0001] This application is a national stage of PCT International Application No. PCT/EP2005/001283, filed February 9, 2005, which claims priority under 35 U.S.C. § 119 to German Patent Application No. 10 2004 007 056.3, filed February 13, 2004, the entire disclosures of which are herein expressly incorporated by reference.

**BACKGROUND AND SUMMARY OF THE INVENTION**

[0002] The present invention relates to a device and a method of producing a peripherally closed hollow profile.

[0003] German patent document DE 195 30 056 A1 discloses a method of the generic type in which a branch is supported at its cap by a yielding counterholder while it is being shaped from a hollow profile blank by means of internal high pressure. In the marginal region of the cap, the branch has a large radius, so that only its center region bears against the end face of the counterholder. The supporting surface formed by the end face of the counterholder is enclosed by a collar-like, concave cutting edge. The center region of the cap of the branch is thus located in a hollow of the counterholder.

[0004] After the desired height of the branch is reached, the forming pressure is considerably increased, so that the radius in the marginal region of the cap of the branch decreases and the latter is pressed against the vertically projecting cutting edge. As a result, the cutting edge cuts an encircling groove in the cap. The counterholder is now displaced toward the branch against the

shaping direction of the branch, so that the cutting edge of the counterholder cuts completely through the cap. In the process, the counterholder plunges into the resulting opening of the branch. A calibrating bead axially adjoining the cutting edge smooths the inner wall of the branch.

**[0005]** Considerable cost is required in order to produce this cutting edge of special design. Furthermore, this cutting edge of special design is subjected to extremely pronounced loading by the increased internal pressure above the forming pressure, a factor which relatively quickly leads during operation to chipping at the cutting edge and thus results in a short service life of the counterholder.

**[0006]** On account of the described high susceptibility of the cutting edge to the high, fluidic and mechanical loads, reliable severing of the cap in the series production process is not possible. After damage to the cutting edge, the stamping of the openings at the branch is effected only incompletely, and as a result the component thus produced has to be scrapped. The costs arising here are considerable, which, in addition to the increased use of material, also include the downtimes for re-setting or repairing the counterholder.

**[0007]** One object of the present invention is to provide a method of the generic type for producing a hollow profile having secondary features and/or branches, which method reliably severs the cap of the secondary feature or of the branch, in a simple manner.

**[0008]** Another object of the present invention is to provide a device for carrying out the method.

[0009] These and other objects and advantages are achieved by the method and apparatus according to the invention, which is based on the surprising knowledge that the cap of the secondary feature and/or of the branch can be neatly severed, even at an internal high pressure which corresponds at most to the forming pressure for forming the hollow profile from the blank. Unlike in the prior art, the severing of the caps is effected solely by a stroke of the counterholding punch in the opposite direction to the expansion direction of the hollow profile. In the process, the end face of the counterholding punch runs in a continuously even manner and thus has no cutting or severing contours of special design. As a result, not only is the counterholding punch of markedly simpler configuration, which considerably reduces the outlay in terms of equipment, but the end face and the severing contour of the counterholding punch also become less susceptible to mechanical loads, which ensures especially long durability of the severing contour of the counterholding punch.

[0010] The internal high pressure does not have to exceed the forming pressure in order to sever the cap of the secondary feature and/or of the branch. Rather, the forming pressure normally applied, or pressures which do not exceed the forming pressure, are sufficient to neatly sever the cap, a factor which additionally relieves the severing contour. Excessive outlay in terms of equipment is not necessary for this purpose, the outlay being necessary at pressures which exceed the forming pressure. The closure force for the hydroforming tool can only be applied by extraordinarily powerful hydraulic cylinders and an extremely robust press frame. However, the width of the

annular gap between the wall of the passage (which is formed in the forming tool and in which the punch is guided in a displaceable manner), and the punch circumference should correspond approximately to the wall thickness of the secondary feature or of the branch. Otherwise, hollow profile material can be displaced into the annular gap by means of the internal high pressure during the shaping of the branch or of the secondary feature. Such displacement into the annular gap may lead to an undesirable shape of the branch or of the secondary feature and also to premature severing of the cap on account of the hollow profile material bearing against the severing contour. Therefore, the invention achieves reliable severing of the cap of the secondary feature or of the branch, in a simple manner.

**[0011]** In an exemplary embodiment of the invention, after the severing operation by a plunging movement of the counterholding punch into the opened secondary feature and/or the branch, the secondary feature and/or the branch is calibrated by means of a calibrating contour corresponding to the shape of the secondary feature or of the branch. The calibrating contour adjoins the punch end on the side facing away from the hollow profile. A number of practical tests have shown that the known encircling bead is not necessary in order to calibrate the secondary feature or the branch. On the contrary, it may be dispensed with in a simple manner, which substantially simplifies the configuration of the counterholding punch. The configuration of the counterholding punch is merely to be adapted to the desired shape of the branch or of the secondary feature.

[0012] In another exemplary embodiment of the device according to the invention, an encircling collar is formed on the counterholding punch and directly adjoins the calibrating contour on the side facing away from the hollow profile. The exemplary embodiment ensures that the inhomogeneous material distribution of the secondary feature or of the branch which occasionally occurs due to the calibration and which leads to an unevenly drawn-in margin of the branch or of the secondary feature is made more uniform by the collar being pressed axially onto the end edge, obtained by the trimming, of the secondary feature or of the branch. The end edge, which is of high quality on account of its evenness and as a result of the almost tolerance-free design, has a favorable effect for subsequent processes for connecting the hollow profile to further components. The further components may be fastened to the branch or the secondary feature in the sense that the joining gap between the end edge and the component is of uniform size. Therefore, a homogeneous joint which thus provides an especially good long-term hold, is achieved. In this case, joining techniques such as welding, adhesive bonding or the like can be used in a reliable manner.

[0013] In a further exemplary embodiment of the device according to the invention, the punch end which contains the severing contour is of frustoconical design and has bevel surfaces facing the secondary feature or the branch. Due to the conical shape of the counterholding punch, a radially encircling sealing seat is produced on the branch or secondary feature, as a result of which a pressure drop inside the hollow profile is prevented in a most advantageous manner.

Thus, by means of a plurality of stamping counterholding punches arranged at the hollow profile, a plurality of branches can be opened simultaneously or one after the other. In other words, the cap can be severed from the branch without the internal high pressure in the hollow profile dropping and thereby resulting in inadequate process reliability.

[0014] In another exemplary embodiment according to the invention, the end edge of the counterholding punch, which forms the severing contour is rounded, which also prevents a severing operation from occurring during the shaping of the branch or of the secondary feature. In this way, during the subsequent deliberate severing of the cap, the same is not stamped out sharply but rather is torn out by the counterholding punch, as a result of which an undefined opening margin is produced, which, however, is smoothed by the subsequent calibration and therefore leads to the desired production result.

[0015] Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0016] The invention is explained in more detail below with reference to two exemplary embodiments shown in the drawings, in which:

[0017] Fig. 1 shows a lateral longitudinal section of a device according to the invention in the expansion phase of the hollow profile, with yielding counterholding punch;

[0018] Fig. 2 shows a lateral longitudinal section of the device from figure 1 after completion of the hollow profile expansion, with a counterholding punch severing the cap of the shaped secondary feature;

[0019] Fig. 3 shows a cutaway side view of a counterholding punch of a device according to the invention, with a calibrating contour adjoining the punch end at the rear; and

[0020] Fig. 4 shows a cutaway side view of a counterholding punch of a device according to the invention, with an encircling collar.

#### **DETAILED DESCRIPTION OF THE DRAWINGS**

[0021] Shown in Figure 1 is a device 1 which comprises a hydroforming tool 2 and with which a peripherally closed hollow profile 3, which is inserted into the hydroforming tool 2, serves with a secondary feature and/or a branch 4. Furthermore, the device 1 contains a counterholding punch 5 which is integrated in the forming tool 2 in such a way as to be displaceable with little clearance.

[0022] To form the hollow profile 3, a hollow profile blank 23 inside the hydroforming tool 2 is put under such a fluidic internal high pressure  $P_i$  that said hollow profile blank 23 expands and comes into contact with the cavity 6 of the forming tool 2, in which the blank 23 is inserted, in such a way as to conform to the contour. In the region of a passage 7 which is formed in the forming tool 2 and in which the counterholding punch 5 is accommodated in a displaceable manner, the hollow profile material is displaced into said passage 7 as a result of the internal high pressure  $P_i$  and forms a secondary feature or the branch 4 in the process. To shape the branch 4 in a reliable manner in terms of the process,

it is supported by the end face 8 of the counterholding punch 5 while it is being produced. The punch 5 yields in the arrow direction with increasing shaped length of the branch 4. In order to deliver sufficient hollow profile material into the expansion region of the branch 4, two axial punches 9 of the device 1 are provided. The axial punches 9 act upon the hollow profile 3 on both ends in a sealing manner and advance both ends 10 in the arrow direction in the direction of the expansion region during the expansion.

**[0023]** As shown in Figure 2, after the desired branch length has been achieved, the drive of the counterholding punch 5 is reversed, so that the latter plunges into the secondary feature or the branch 4 and in the process severs its cap 11. A hole slug is formed by means of a severing contour which is formed by the end edge 12 of the punch 5. The severing process takes place according to the arrow direction with a force  $F$ . In the meantime, a pressure which corresponds to or is lower than the forming pressure prevails in the hollow profile 3. The end face 8 enclosed by the end edge 12 of the punch 5 runs in a continuously even manner. In order to permit problem-free plunging into the branch 4, the width of the annular gap 22 between the circumference 13 of the punch 5 and the passage wall 14 is dimensioned in such a way that it corresponds approximately to the wall thickness of the secondary feature or of the branch 4. The cap 11 of the branch 4 is therefore severed solely by a stroke of the counterholding punch 5 in the opposite direction to the expansion direction of the hollow profile 5. After the pressure is released, the hydroforming tool 2 is opened and the finish-formed and processed hollow profile 3 is removed.

**[0024]** As can be seen from Figures 1 and 2, the counterholding punch 5 can be of continuously cylindrical design. In deviation therefrom, the punch end 15 which faces the branch 4 and contains the severing contour may be of frustoconical design according to Fig. 3, in which case it has bevel surfaces 16 facing the secondary feature or the branch 4. The opened branch 4 is sealed off in a completely pressure-tight manner via these bevel surfaces 16. As a result, a pressure drop inside the hollow profile 3 is avoided, so that branches 4 formed at other points of the hollow profile 3 can be effected sequentially in a reliable manner in terms of the process by severing the cap by means of a counterholding punch 5 arranged there in each case.

**[0025]** In deviation from the preceding exemplary embodiment of the configuration of the counterholding punch 5, as can be seen from Figure 3, a counterholding punch 17, according to Figure 4, in another exemplary embodiment, additionally has a calibrating contour 18, which, on that side of the punch 17 which faces away from the hollow profile, adjoins the punch end 19 and is designed in accordance with the contour of the secondary feature or of the branch. In this way, when the counterholding punch 17 plunges deeper into the branch 4, the region of the opening on the branch, this region being formed by the cap trimming, is readily smoothed to a sufficient extent in accordance with the desired shape. This provides for optimum connection to further components which have to be put into or onto the branch of the hollow profile 3.

**[0026]** Furthermore, an encircling collar 20 of the counterholding punch 17 directly adjoins the calibrating contour 18 on the side facing away from the

hollow profile. The collar 20 acts upon the end face of the opening margin of the branch, thereby ensuring uniform evenness of this end face. If need be, the end edge 21 of the counterholding punch 17 may also be rounded in order completely to prevent an encircling predetermined breaking point from being produced during the supporting function of the counterholding punch 17. The predetermined breaking point may burst open at least locally on account of the prevailing internal high pressure, whereupon the further formation of the branch 4 can no longer be effected in a reliable manner in terms of the process. Nonetheless, after the supporting function of the counterholding punch 17 has been dispensed with, the cap 11 can still be severed from the branch 4 by the rounded end edge 21 of the punch end 19.

**[0027]** The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.